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Research accomplishments are briefly reviewed in this final report.

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FINAL REPORT

Ionically and Electronically Conductive

Composite Polymer Membranes

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The proposed research had two objectives - 1) To investigate selectivity and facility of ion-transport in novel ionically-conductive composite polymer membranes. These membranes were prepared by incorporating an ion exchange polymer into the pore system of a microporous support membrane. 2) To investigate ion transport and electronic conductivity in electronically conductive polymers which had a "molecular-engineered" fibrillar morphology. This unique fibrillar morphology was obtained by synthesizing the polymer within the pores of a microporous host membrane. These membranes contained linear, cylindrical pores, with equivalent pore diameters. We call this process "Template Synthesis" because the pores in the membrane act as templates for the nascent electronically conductive polymer.

Research accomplishments have been reviewed in detail in 20 research articles published in refereed scientific journals (1-20). Hence, a detailed review of accomplishments will not be presented here. However, in the area of ionically conductive composites, we have investigated the properties of membranes prepared by incorporating the perfluorosulfonate ionomer Nafion into the microporous perfluorcarbon membrane Gore-tex. We have shown that, in essence, membranes with an unlimited variety of transport properties can be prepared by varying the amount of Nafion

incorporated into the Gore-tex membranes.

There is a trade-off between cation-transport selectivity and cation-transport facility in these membranes. Highly cation-selective membranes require that relatively large amounts of Nafion be incorporated into the Gore-tex host. In contrast, cation-transport facility increases as the quantity of Nafion incorporated decreases. This allows for the transport properties of a membrane to be "tuned" to the particular application.

In the area of electronically-conductive polymers, we have shown that polyheterocyclics (e.g. polypyrrole and polythiophene) can be synthesized within the pores of microporous Nuclepore membranes. This "Template Synthesis" yields electronically conductive polymer fibrils. We have shown that ion-transport in films composed of such fibrils can be dramatically higher than films of these polymers prepared by conventional electrochemical synthesis. This observation has important implications for any application of such polymers where facility of ion-transport is important, for example battery applications.

Just as important as the increase in ion-transport facility, we have shown that these fibrillar versions of the heterocyclic polymers can have dramatically higher electronic conductivities than conventional versions of the analogous polymers. Interestingly, electronic conductivity along the axes of such fibrils decreases with the diameter of the fibril. We have prepared 30 nm-diameter poly(3-methylthiophene) fibrils with electronic conductivities as high as 6600 S cm^{-1}. This is the highest conductivity ever reported for a polyheterocyclic.

PROJECT SUMMARY

Ionically and Electronically Conductive Composite Polymer Membranes

The proposed research had two objectives - 1) To investigate selectivity and facility of ion-transport in novel ionically-conductive composite polymer membranes. These membranes were prepared by incorporating an ion exchange polymer into the pore system of a microporous host membrane. 2) To investigate ionic and electronic conductivity in electronically conductive polymers which have a unique fibrillar morphology. This fibrillar morphology was obtained by synthesizing the polymer within the pores of a microporous membrane; we call this method "Template Synthesis." Research accomplishments have been reviewed in detail in 21 research articles published in refereed scientific journals. We have shown that ionically conductive composite membranes showing both high cation-transport selectivity and high cation-transport rates can be obtained. We have also shown that ionic and electronic conductivity can be dramatically enhanced by conducting "Template Synthesis" on electronically conductive polymers.

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